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(54) Title: A PROCESS AND APPARATUS FOR BRINE REFORMATION

(57) Abstract: The present application relates to a reformation process of brine solution formed following loading of the ion-exchange resin used for water softening. The cyclic, continuous process for brine reformation comprising the steps: (I) a brine solution containing bivalent cations, in particular calcium, magnesium, iron and manganese ions, is transferred to a Hardness Precipitation System (Station 1) in which, at a suitable pH, same cations are removed as carbonate and/or sulphate salts, in a precipitation form, resulting in a semi-reformed brine solution containing sodium chloride in a typical concentration of 1 % to 2 % by weight; said semi-reformed brine solution is optionally subjected to a pH adjustment step (Station 2); (II) following said optionally pH adjustment the semi-reformed brine solution is transferred to a Reverse Osmosis System (Station 3) in which an increase of NaCl concentration is accomplished, providing a reformed brine solution suitable for regenerating an ion-exchange resin applicable in water softening process; (III) Applying the reformed brine solution in regeneration of an ion-exchange resin.

A PROCESS AND APPARATUS FOR BRINE REFORMATION

The present invention relates to a reformation process of brine solution formed following loading of the ion-exchange resin used for water softening. More specifically, it relates to a new environmental friendly salt and water conservation system which allows safely removal of potential undesired bivalent cations, while reforming brine solution. The reformed brine solution is applicable for regeneration of ion-exchange resins used in water softening processes.

Hard waters may be softened by passage through beds of ion exchange media. Ion exchangers are beds of zeolites, carbonaceous materials or resinous substances. Depending upon their nature and that of the ions exchanged, the beds are regenerated with salt, acid, sodium carbonate or sodium hydroxide. The hardness of water is due to its calcium and magnesium content.

One widely used process for softening residential and industrial process water is sodium cation exchange. This process involves the passing of hard water through a bed of resin enriched, or loaded, with sodium ions. The treated water (soft water) is almost free of calcium and magnesium and now contains an increased level of sodium due to the exchange properties of the resin. When the sodium ions in the resin bed are diminished it is necessary to regenerate the ion-exchange resin with sodium ions, and this may be done by adding sodium chloride containing solutions.

Since sodium chloride is consumed to produce soft water, salt-saving techniques have been developed, among them are brine reclamation, namely reuse the brine for subsequent ion-exchange regeneration.

Softeners use an excess of salt during brining. Normally this excess salt (in particular, the chloride salts of sodium, calcium, magnesium, manganese and iron) goes into a sanitary sewer system and then to a stream, river or municipal waste water treatment plant. Salt pollution is an evolving problem in many countries, particularly countries which have extended dry seasons where rivers and streams may dry substantially. Salt concentrations (in particular, chloride concentrations) during dry seasons may grow to harmful levels, resulted in endangering wildlife and ecological-systems.

Consequently, it is an urgent need for a highly efficient process which both substantially reduces water and salt discharging into the sewer systems and at the same time discharges bivalent cations as non-hazardous precipitants. More specifically, a high efficient process for reformatting the brine solution formed following regeneration of ion-exchange resin used in water softening processes, is an urgent environmental demand.

In order to avoid the release of brine containing salts to the sewer, systems were developed in which regeneration of the brine solution is carried out.

Autocatalytic Sales of Elmhurst, Illinois, USA, provides a salt conservation system comprising the step of adding sodium carbonate into a container containing brine solution and let calcium and magnesium settle to the bottom as carbonates whereas the remaining brine is decanted off. A shortcoming of this process is derived from the fact that decanted brine contains suspended particles of bivalent salts that do not precipitate under such conditions. A small amount of muriatic acid is added and some additional sodium chloride is added for refortification, unlike the process of present invention in which addition of NaCl is not required at all.

Considering the above described method for brine reformation, it was surprisingly found that carrying out the carbonate/sulphate precipitation step in a Hardness Precipitation System, preferably in a micrifiltration apparatus, and most preferably in a crossflow type, combined with a Reverse Osmosis System (R/O), provides an economical, high efficient, continuous process, that yields a better result, with more solid waste removed to filter-press.

Thus, it is the object of present invention to provide a new process for reformation of a brine solution, and the use of same reformed brine for regeneration of an ion-exchanger used in a process of water softening. An additional object of present invention is to provide a cyclic process for regenerating the ion-exchanger used in water softening. It is yet a further object of present invention to provide a Hardness Precipitation System, preferably in a microfilter equipment, and most preferably of a crossflow type, for removing bivalent cations, accumulated during the loading process of an ion-exchanger used in water softening. More specifically, it is an object of present invention to use the Hardness Precipitation System for replacing undesired bivalent cations (in particular, calcium, magnesium, iron and manganese ions), with monovalent cations (in particular, sodium ions). An additional object of present invention is to provide a process for continuous reformation of brine solution, comprising the steps of replacing bivalent cation ions, with sodium ions, removing the bivalent cations in a precipitate form and subsequently increasing the concentration of the sodium ions to meet the concentration range required for regeneration of the ion-exchange resin by means of R.O. system.

DESCRIPTION OF THE FIGURES

Fig. 1: A flow-diagram demonstrating the steps involved in a cyclic, continuous brine reformation process; and

Fig. 2: A flow-diagram outlining the process described in the Example.

DESCRIPTION OF THE INVENTION

The present invention provides a new system and apparatus for cyclic, continuous brine reformation process and for an ion-exchanger cyclic regeneration, comprising the following steps (Fig. 1):

1. Upon regeneration of the Ion Exchange Softener, a brine solution is formed (Exhausted Brine) containing the released bivalent cations, in particular, calcium, magnesium, iron and manganese ions.
2. The brine solution is transferred to the Hardness Precipitation System, preferably consisting of microfiltration system, and most preferably of cross-flow type, for removing, optionally in an elevated pH, same bivalent metal ions and silica in the form of either carbonate or sulphate precipitants, resulting in a semi-reformed brine solution containing sodium chloride in a concentration of 1 to 2% by weight.
3. Said semi-reformed brine solution is optionally subjected to a pH adjustment step. pH may be optionally adjusted by adding either an acid

or CO_2 in order to prevent sedimentation of carbonates and/or sulphates in the regenerated ion-exchanger.

4. The semi-reformed brine solution is transferred to a Reverse Osmosis System (R/O system) to re-establish NaCl concentration suitable for ion – exchanger regeneration purposes. The permeate of the R/O system is transferred for consumption with soft water and the retainat, being a reformed brine solution, is transferred to a reservoir (Brine).
5. Applying the reformed concentrated brine solution for regenerating the Ion-Exchange Softener with sodium ions.

The following example is provided merely to illustrate the invention and is not intended to limit the scope of the invention in any manner.

EXAMPLE (Fig. 2)

A brine solution containing 5% NaCl (by weight) was transferred through an Ion Exchange Softener (ion-exchange softener resin, Bayer), in a daily average flow rate of 150 liter per hour. The brine solution that was released from the ion-exchanger bed (Exhausted Brine) contained 1% (by weight) of bivalent metals calculated as $CaCl_2$. Said brine solution was passed through a microfilter of crossflow type (Memtek-U.S.F) in a rate of 150 liter per hour to which powdered lime (calcium hydroxide) was added for adjusting the pH to 10.5, followed by addition of soda ash (sodium carbonate) in an amount of 1 mole soda ash per mole calcium carbonate. 1.6 kg (calculated as dry material) of corresponding bivalent metal salts, in a precipitate form, were removed from filter-press as wet solid waste, including the carbonate salts of calcium, magnesium, manganese, and iron and/or their respective hydroxide compounds.

The semi-reformed brine solution which was released from the microfilter unit contained 1.5% NaCl (by weight). 15% HCl solution was added to adjust the pH to about 7. Said semi-reformed brine solution was pumped to a R/O membrane system (U.S. Filter) from which the permeate is sent in a rate of 105 liter per hour to soft water consumption and the retainat, being a reformed brine solution having 5% NaCl, is accumulated in the brine reservoir container, at a rate of 46 l/h from which it is transferred for regenerating the same Ion-Exchange Softener in a cyclic pattern.

CLAIMS

1. A cyclic, continuous process for brine reformation comprising the steps:

(I) a brine solution containing bivalent cations, in particular calcium, magnesium, iron and manganese ions, is transferred to a Hardness Precipitation System (Station 1) in which, at a suitable pH, same cations are removed as carbonate and/or sulphate salts, in a precipitation form, resulting in a semi-reformed brine solution containing sodium chloride in a typical concentration of 1% to 2% by weight; said semi-reformed brine solution is optionally subjected to a pH adjustment step (Station 2);

(II) following said optionally pH adjustment the semi-reformed brine solution is transferred to a Reverse Osmosis System (Station 3) in which an increase of NaCl concentration is accomplished, providing a reformed brine solution suitable for regenerating an ion-exchange resin applicable in water softening process;

(III) Applying the reformed brine solution in regeneration of an ion-exchange resin.

2. A process according to claim 1, wherein Station 1 comprises a microfiltration apparatus.

3. A process according to claim 2, wherein Station 1 comprises a cross-flow microfiltration apparatus.

4. A process according to any one of claims 1 to 3, wherein hydroxides such as lime/caustic are used in Station 1 to elevate the pH, and carbonates or sulfates are used for precipitating said bivalent cations.

5. A process according to claim 4, wherein calcium hydroxide is added to obtain pH of 9 to 12, and preferably 10.5.

6. A process according to any one of claims 1 to 3, wherein sulphates are used in Station 1 for precipitating said bivalent cations.

7. A process according to any one of claims 1 to 6, wherein precipitated carbonate and sulphate salts are removed from Station 1 by filter press system, retaining a semi-reformed brine solution.

8. A process according to any one of claims 1 to 7, wherein said semi-reformed brine solution formed in Station 1 contains about 1.5% sodium chloride (by weight).

9. A process according to any one of claims 1, 4 and 5, wherein acid is added in Station 2 to said semi-reformed brine solution, maintaining a pH that prevents sedimentation of carbonates and/or sulphates when reformed

brine solution is used in regeneration process of an ion-exchanger applicable in water softening.

10. A process according to claim 9, wherein said acid is HCl.

11. A process according to claim 1, wherein said semi-reformed brine solution is processed in Station 3 to re-establish NaCl concentration suitable for regeneration of ion-exchanger applicable in water softening.

12. A process according to claim 11, wherein the permeate formed in Station 3 is transferred for consumption with soft water and the retainat, being a reformed brine solution, is transferred to a reservoir.

13. A process according to claim 12, wherein the retainat containing 3 to 15% (by weight) of sodium chloride.

14. A process according to claim 13, wherein the concentration of sodium chloride is 10% by weight.

15. A process according to claim13, wherein the concentration of sodium chloride is 5% by weight.

16. A process according to any one of claims 1, 4 and 5, wherein CO_2 is used in station 1 as a precipitating agent providing carbonate ions.

17. A process according to claim 16, wherein CO_2 is added for adjusting pH in station 2 with or without addition of HCl.

18. A process according to claim 1, substantially as described in the specification.

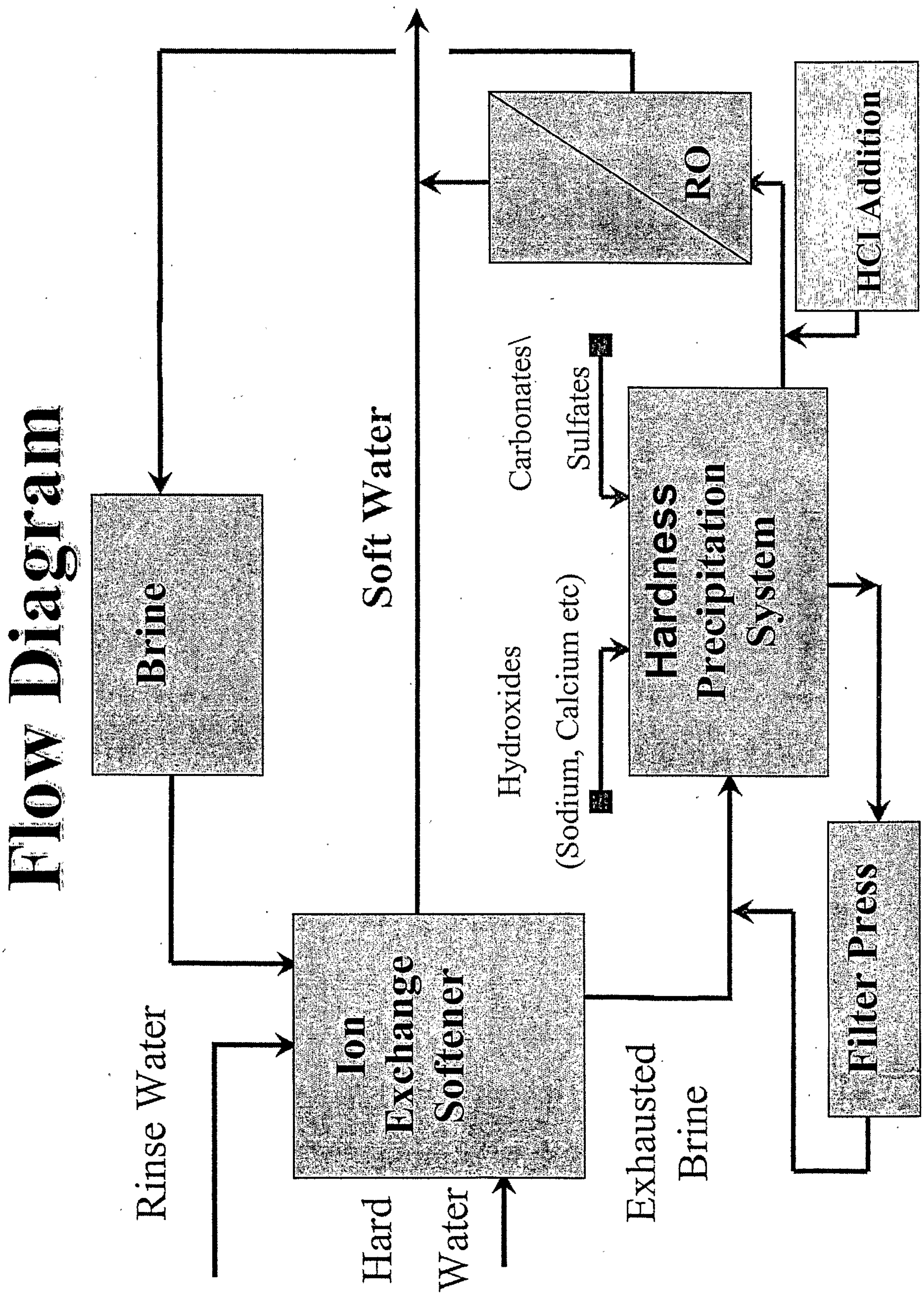
Flow Diagram
Brine
Soft Water
RO
HCl Addition
Carbonates\
Sulfates
Hydroxides
(Sodium, Calcium etc)
Hardness
Precipitation
System
Rinse Water
Ion
Exchange
Softener
Hard
Water
Exhausted
Brine
Filter Press

Fig. 1

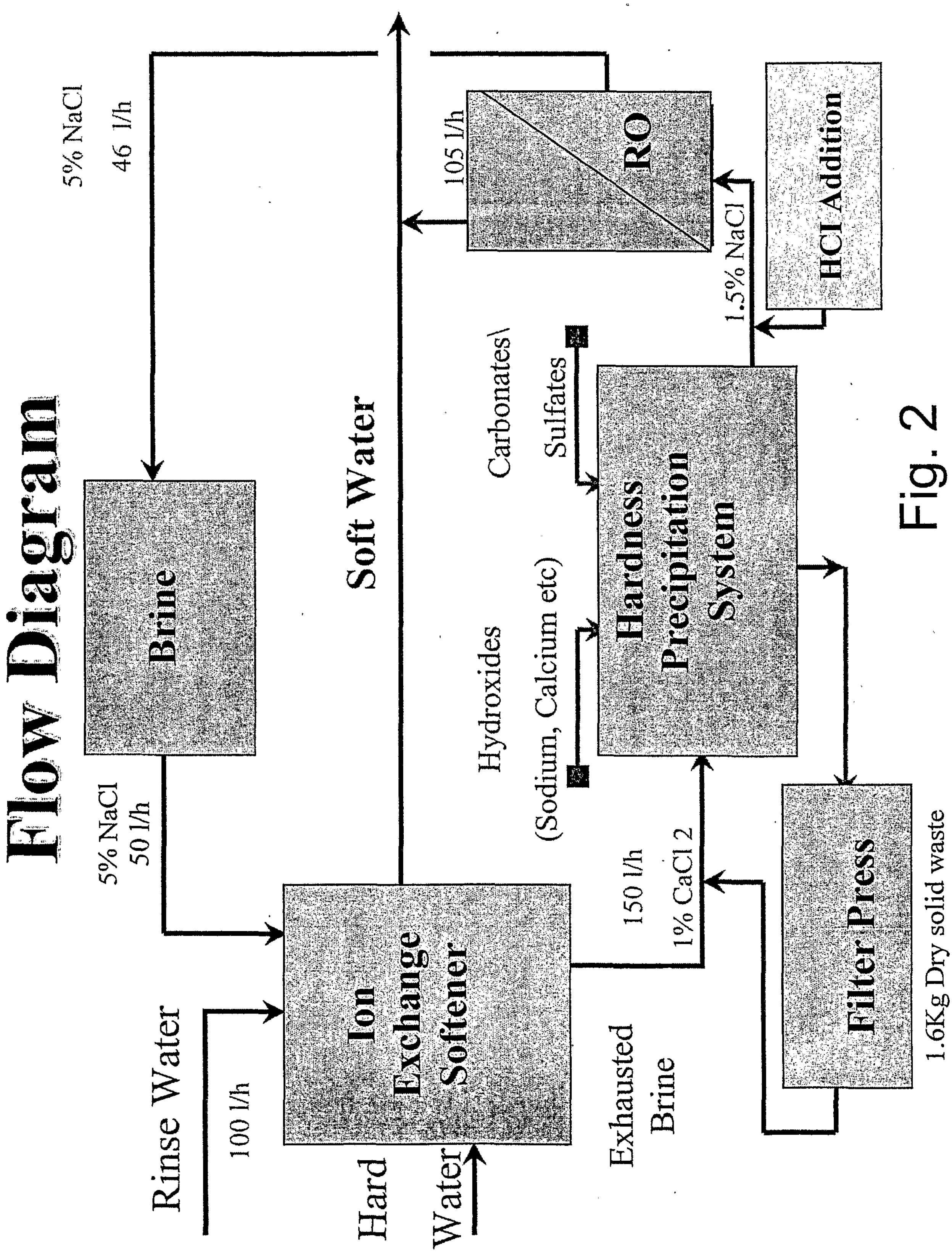
Flow Diagram
Rinse Water
100 l/h
Hard Water
Ion Exchange Softener
5% NaCl
50 l/h
Brine
5% NaCl
46 l/h
Soft Water
105 l/h
RO
HCl Addition
1.5% NaCl
Carbonates\
Sulfates
Hydroxides
(Sodium, Calcium etc)
Hardness Precipitation System
Exhausted Brine
150 l/h
1% CaCl 2
Filter Press
1.6Kg Dry solid waste

Fig. 2